Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Coal Research Laboratories

Laboratoires de recherche sur le charbon

Canada

PRELIMINARY CERCHAR HARDNESS DATA, SYDNEY COALFIELD, N.S.

M.L. Musial, G.R. Corbett, D.G. Chipman and T.R.C. Aston

Division Report CRL 89-20(TR)
February 1989

This document is an unedited interim report prepared primarily for discussion and internal reporting purposes. It does not represent a final expression of the opinion of the Canada Centre for Mineral and Energy Technology (CANMET)

Ce document est un rapport provisoire non-révisé et rédigé principalement pour fin de discussion et de documentation interne. Il ne représente nullement l'expression définitive de l'opinion du Centre canadien de la technologie des minéraux et de l'énergie (CANMET)

MICROMEDIA

25 pp

89-06209/

PRELIMINARY CERCHAR HARDNESS DATA, SYDNEY COALFIELD, N.S.

by

M.L. Musial*, G.R. Corbett**, D.G. Chipman** and T.R.C. Aston***

SUMMARY

The report presents preliminary hardness data obtained from core and irregular samples of sandstone, siltstone and mudstone collected from the Lingan and Prince Mines, Sydney Coalfield, N.S. The effect of multiple hardness testing using a single hardness stylus is also discussed.

---

*Mineral Technology Student, Cape Breton Development Corporation, Glace Bay, **Field and Laboratory Technologist and ***Research Scientist, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney.

DONNÉES PRÉLIMINAIRES DE DURETÉ CERCHAR
BASSIN HOUILLER DE SYDNEY (N.-É.)

par

M.L. Musial*, G.R. Corbett**, D.G. Chipman** et T.R.C. Aston***

RÉSUMÉ

Ce rapport présente les données préliminaires de dureté obtenues à partir de carottes et d'échantillons de forme irrégulière de grès, d'aleurolite et de pélite prélevés dans les mines Lingan et Prince dans le bassin houiller de Sydney (N.-É.). On examine également l'effet d'essais multiples de dureté à l'aide d'une pointe de dureté unique.

---

*Étudiant en technologie minérale, Société de développement du Cap-Breton, Glace Bay, **technologue de terrain et de laboratoire et ***chercheur, Laboratoire du Cap-Breton, Laboratoires de recherche sur le charbon, CANMET, Énergie, Mines et Ressources, Sydney.

CONTENTS

	Page
SUMMARY	i
SOMMAIRE	iii
INTRODUCTION	1
TEST PROGRAM	1
TEST PROCEDURE	3
DISCUSSION	5
CONCLUSION	13
REFERENCES	13
APPENDIX A	15
APPENDIX B	17
APPENDIX C	19

TABLES

No.		Page
1.	Hardness testing results, comparison of hardness values for sandstone, siltstone and mudstone	2
2.	Equipment list	3
3.	Hardness testing results for the repetitive use of drill bits	8
4.	CERCHAR hardness and abrasivity results report	9

FIGURES

1.	Engraved hardness drill bit	4
2.	Sample hardness curves	6
3.	Hardness curve measuring device and technique	7
4.	Comparison of drill bit wear on samples with different degrees of hardness	12

INTRODUCTION

Knowledge regarding the hardness and abrasivity of different strata types can be invaluable for improving the advance rates and reducing the operating costs of mining equipment, such as roadheaders and TBM's (1).

In 1987, a multi-year research program was established by the Cape Breton Coal Research Laboratory to investigate rock cuttability and machine performance in the Sydney Coalfield, N.S. (2). The initial objectives of the program were to establish a test methodology and abrasivity/hardness index system, developed from the laboratory testing of field samples (3,4). This report presents the preliminary hardness data obtained from core and underground 'hand-sized' specimens collected from the Lingan and Prince Mines. In addition, the effect of multiple testing on a single hardness stylus is also discussed. Preliminary abrasivity data has already been reported elsewhere (5).

TEST PROGRAM

The test program had two main objectives:

1) Establish the CERCHAR Hardness Indices (CHI's) of a Sandstone, Siltstone and Mudstone Sample

As stipulated in the CERCHAR operator's manual, only the first test performed using a new bit (or stylus) produces a hardness curve acceptable for determining a CHI value (6). Three tests were therefore performed on each core sample (Appendix A) and the mean value taken as the specimen CHI index, Table 1.

2) Evaluate the Effect of Multiple Testing on a Single Hardness Stylus

The CERCHAR hardness manual specifies that each stylus can only be used once for determining a hardness index. Three individual bits were therefore subjected to multiple testing (approximately ten runs) in order to establish a pattern of bit wear. The determination of a 'bit wear pattern' may indicate that several tests can be done with each stylus, therefore reducing the overall testing and resharpening costs.

After completion of these goals, further CHI testing was done on several samples collected from a development face at Prince Mine. The

TABLE 1: HARDNESS TESTING RESULTS

COMPARISON OF HARDNESS VALUES FOR
SANDSTONE, SILTSTONE AND MUDSTONE

DRILL BIT NO.	ROCK TYPE	NO. HOLES DRILLED	LOAD (KG)	CURVE READING	CORRECTION FACTOR *	CAL'D C.H.I.	AVERAGE C.H.I.
91	SANDSTONE	1	20	22.5	x 1.0	22.5	
90		1	20	21.0	x 1.0	21.0	
78		1	40	10.0	X 2.0	20.0	21
93	SILTSTONE	1	20	20.0	x 1.0	20.0	
92		1	20	19.5	"	19.5	
63		1	20	19.0	"	19.0	20
95	MUDSTONE	1	20	15.0	x 1.0	15.0	
94		1	20	15.0	"	15.0	
50		1	20	16.0	"	16.0	15

* STANDARD TESTS ARE DONE USING A LOAD OF 20.0 KILOGRAMS. TESTING MAY ALSO BE DONE USING A 7 KILOGRAM LOAD FOR SOFTER SAMPLES OR A 40 KILOGRAM LOAD FOR HARDER SAMPLES. A CORRECTION FACTOR IS USED TO CONVERT OR NORMALIZE C.H.I. VALUES, DETERMINED FROM USING 40 AND 7 KG LOADS, TO VALUES EQUAL TO THOSE WHICH WOULD RESULT FROM THE STANDARD 20 KILOGRAM TEST.

identification of each sample remained unknown to the operator until after testing was completed. This eliminated potential operator bias and allowed an objective comparison of the results with those previously obtained from the known core samples.

TEST PROCEDURE

Instrumentation employed for the hardness testing program is listed in Table 2:

Table 2 - Equipment list

1) CERCHAR Hardness Apparatus
2) 100 Tungsten Carbide Hardness Bits
3) Compressed Air Supply
4) Hardness Bit Holder (developed by CBCRL)
5) Hardness Bit Transportation Case (developed by CBCRL)
6) Curve Measuring Device (supplied with hardness apparatus)
7) Dremel Electric Engraver with Diamond Tip

One hundred (100) hardness bits were numbered by engraving to ensure easy identification, Figure 1.

Three samples were selected from Lingan core stored at CBCRL (Appendix A) and nine hand-sized specimens collected from Prince Mine. Each sample was properly tagged and logged when collected. No special precautions were adopted during sample collection, except to ensure that each specimen was large enough to facilitate multiple testing. Samples containing fractures were avoided, since they might produce erroneous results.

The CERCHAR hardness apparatus was examined and its penetration depth gauge set to exactly 1.0 cm as specified by the CERCHAR manual.

A rock sample was then secured in the vice of the apparatus and positioned so that the hole could be properly drilled in the desired area. A used bit was placed in the chuck and a starter hole drilled. Starter holes are drilled only until the bottom of the hole is perfectly circular, which is usually obtained at a very shallow depth. This provides a perfectly flat area upon which the new, unused bit rests prior to penetrating the rock. A jet of

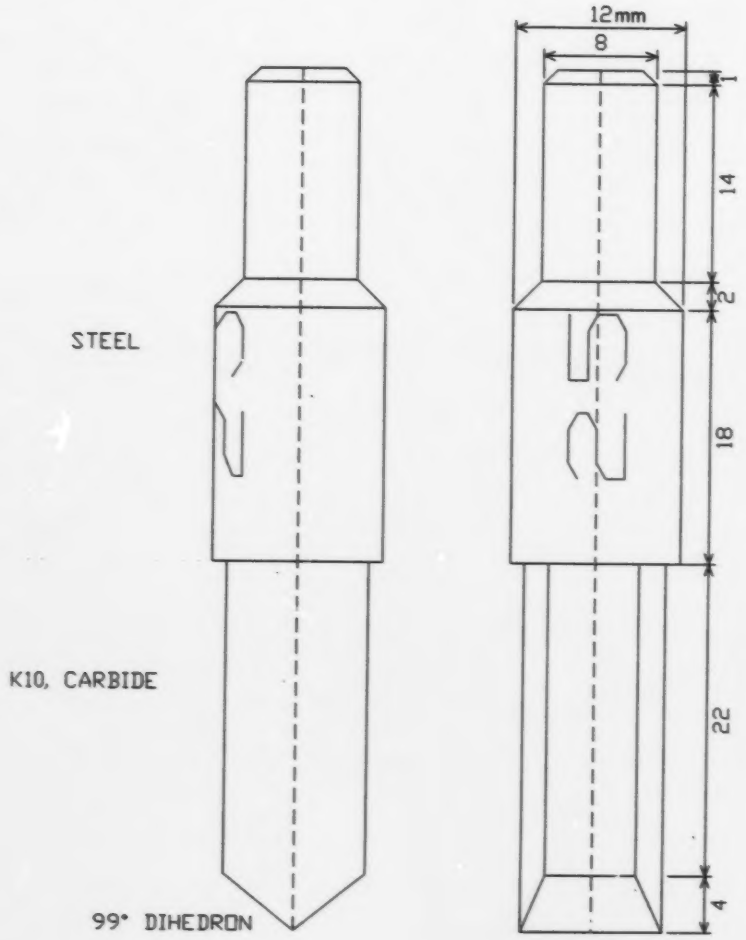


Figure 1 - Engraved hardness drill bit

compressed air is aimed directly at the site of the drill hole to blow away rock dust created by the penetrating bit. A compressed air jet is important because drilling debris would quickly clog the hole and prevent the drill from rotating freely, therefore producing an erratic and inaccurate curve (Figure 2).

Chart paper is set on the drum roll of the apparatus, a ball pen mounted in its holder and a generatrix (origin point) created. The bit used to create the starter hole is then removed and an unused bit inserted in its place. The new bit is then lowered gently, to prevent possible tip damage, onto the sample and drilling started. A hardness curve is then recorded on the chart recorder paper. Several tests can be run using the same chart paper (Appendix B). Once removed from the drum roll, a tangent to the slope of the curves is measured with the supplied measuring device. These measurements provide the means to determine the CHI value of the rock sample tested (Figure 3).

When performing hardness testing, the load that forces the bit into the rock can be varied depending upon the hardness of the sample. A pair of cylindrical weights, attached to the spindle head, supply the load acting on the rock. Three different weights allow the load to be set at 7, 20 or 40 kg. A different load may be required when the rock is very soft or very hard. Standard tests are performed using a 20 kg load and all other tests are corrected to this standard.

Upon completion of the testing, the data was thoroughly examined and subsequently interpreted, Tables 3 and 4. Appendix C contains a point-by-point description of the procedure used in the CERCHAR hardness machine operation.

DISCUSSION

Table 1 shows that the sandstone sample, with an average CHI value of 21, is harder than either the siltstone or mudstone samples which have CHI values of 20 and 15 respectively.

Table 3 shows the results produced from the repetitive use of hardness bits on samples of varing degrees of hardness. Figure 4 shows that the fluctuations in the readings increased with sample hardness. This could

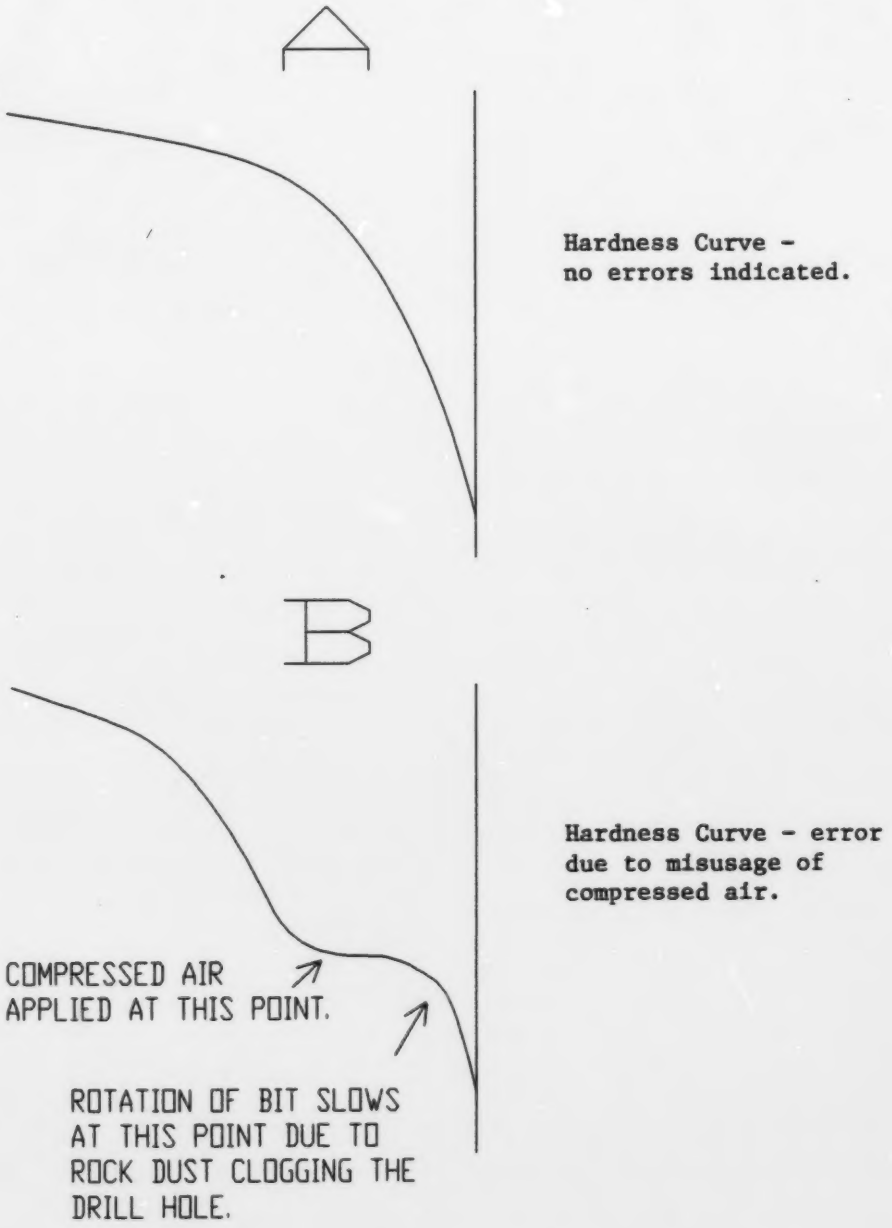


Figure 2 - Sample hardness curves

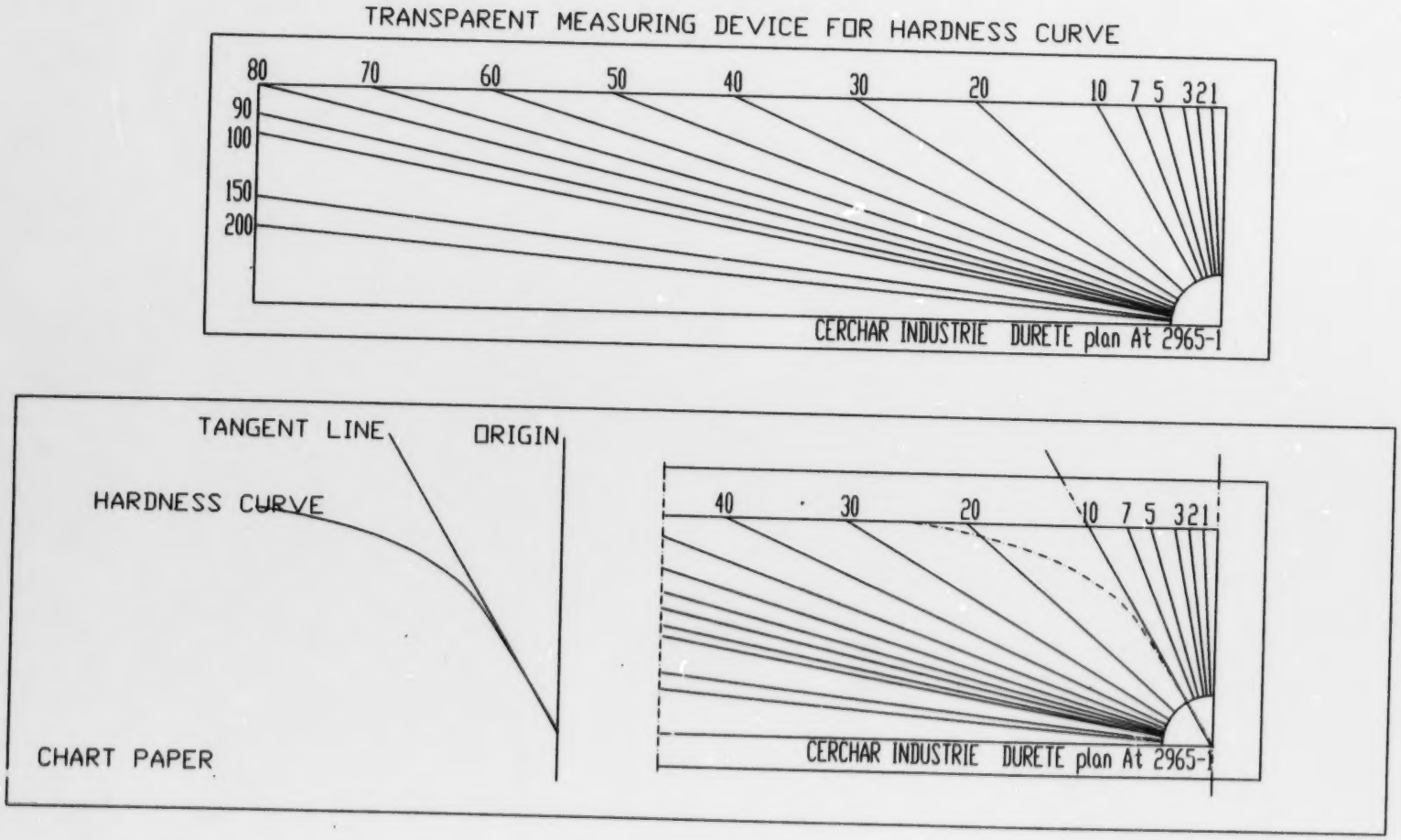


Figure 3 - Hardness curve measuring device and technique

Table 3 - Hardness testing results for the repetitive use of drill bits

DRILL BIT NO.	SAMPLE I.D.	NO. HOLES DRILLED	LOAD (KG)	CURVE READING	CORRECTION FACTOR *	CAL'D C.H.I.	AVERAGE C.H.I.
96	A	1	20	8.0	x 1.0	8.0	
96		2	20	9.0		9.0	
96		3	20	10.0		10.0	
96		4	20	9.5		9.5	
96		5	20	9.5		9.5	
96		6	20	10.0		10.0	
96		7	20	9.5		9.5	
96		8	20	8.0		8.0	
96		9	20	9.0		9.0	
96		10	20	9.0		9.0	9.2
92	B	1	20	19.5	x 1.0	19.5	
92		2	20	18.0		18.0	
92		3	20	16.5		16.5	
92		4	20	16.5		16.5	
92		5	20	16.0		16.0	
92		6	20	16.0		16.0	
92		7	20	18.0		18.0	
92		8	20	18.5		18.5	
92		9	20	20.0		20.0	
92		10	20	18.0		18.0	17.7
95	C	1	20	15.0	x 1.0	15.0	
95		2	20	20.0		20.0	
95		3	20	21.0		21.0	
95		4	20	19.5		19.5	
95		5	20	17.5		17.5	
95		6	20	21.0		21.0	
95		7	20	20.0		20.0	
95		8	20	20.0		20.0	
95		9	20	21.5		21.5	
95		10	20	19.0		19.0	19.5

* STANDARD TESTS ARE DONE USING A LOAD OF 20.0 KILOGRAMS. TESTING MAY ALSO BE DONE USING A 7 KILOGRAM LOAD FOR SOFTER SAMPLES OR A 40 KILOGRAM LOAD FOR HARDER SAMPLES. A CORRECTION FACTOR IS USED TO CONVERT OR NORMALIZE C.H.I. VALUES, DETERMINED FROM USING 40 AND 7 KG LOADS, TO VALUES EQUAL TO THOSE WHICH WOULD RESULT FROM THE STANDARD 20 KILOGRAM TEST.

TABLE 4 : CERCHAR HARDNESS AND ABRASIVITY RESULTS REPORT

CBCRL SAMPLE IDENT.	CBDC SAMPLE IDENT.	SAMPLE DATE	MINE	SAMPLE LOCATION	CBDC ID. SAMPLE TYPE	RUN NO.	CAL'D C.A.I.	CAL'D C.H.I.	OPERATOR COMMENTS \ DESCRIPTION
8	1	09-Dec-88	PRINCE	3 DECLINE	MUDSTONE	1	0.40	4	SLIGHTLY SILTY;
						2	0.00	3	LISTRIC SURFACES PRESENT
						3	0.50	5	(TESTED ON DEC. 13/88)
						4	0.40		
						5	0.20		
						AVG.	0.30	4	
9	2	09-Dec-88	PRINCE	3 DECLINE	SANDSTONE (WET)	1	1.70	7	MEDIUM TO COARSE GRAINED;
						2	1.80	8	FAIRLY MASSIVE
						3	1.80	8	(TESTED ON DEC. 13/88)
						4	1.70		
						5	1.90		
						AVG.	1.78	7	
10	3	09-Dec-88	PRINCE	4 DECLINE	MUDSTONE	1	0.10	4	LISTRIC SURFACES COMMON
						2	0.70	4	(TESTED ON DEC. 13/88)
						3	0.50	4	
						4	0.10	5	
						5	0.50		
						AVG.	0.38	4	
11	4	09-Dec-88	PRINCE	4 DECLINE	SANDSTONE (WET)	1	4.10	6	COARSE GRAINED;
						2	4.10	6	FAIRLY MASSIVE
						3	4.30	6	(TESTED ON DEC. 13/88)
						4	4.30	6	
						5	4.30	6	
						AVG.	4.22	6	

TABLE 4 : CERCHAR HARDNESS AND ABRASIVITY RESULTS REPORT

CBCRL SAMPLE IDENT.	CBDC SAMPLE IDENT.	SAMPLE DATE	MINE	SAMPLE LOCATION	CBDC ID. SAMPLE TYPE	RUN NO.	CAL'D C.A.I.	CAL'D C.H.I.	OPERATOR COMMENTS \ DESCRIPTION
12	5	29-Nov-88	PRINCE	4 DECLINE	SANDSTONE	1	2.00	6	FINE TO MEDIUM GRAINED;
						2	2.00	6	FAIRLY MASSIVE
						3	1.90	7	(TESTED ON DEC. 13/88)
						4	2.10	6	
						5	1.40		
						AVG.	1.88	6	
13	6	08-Dec-88	LINGAN	7 WEST COAL ROAD FLOOR SAMPLE	?	1	0.10	2	TO BE IDENTIFIED BY CBDC GEOLOGISTS
						2	0.50	3	FLOOR SAMPLE
						3	0.20	2	(TESTED ON DEC. 13/88)
						4	0.20		
						5	0.20		
						AVG.	0.24	2	
14	7	16-Dec-88	PRINCE	4 DECLINE	SANDSTONE (WET)	1	1.90	8	TO BE IDENTIFIED BY CBDC GEOLOGISTS
						2	2.10	6	(TESTED ON DEC. 19/88)
						3	2.40	6	
						4	2.10	6	
						5	1.80		
						AVG.	2.06	7	
15	8	16-Dec-88	PRINCE	4 DECLINE	MUDSTONE	1	0.5	3	TO BE IDENTIFIED BY CBDC GEOLOGISTS
						2	0.2	3	(TESTED ON DEC. 19/88)
						3	0.1	3	
						4	0.6	4	
						5	0.4	3	
						AVG.	0.36	3	

TABLE 4 : CERCHAR HARDNESS AND ABRASIVITY RESULTS REPORT

CBCRL SAMPLE IDENT.	CBDC SAMPLE IDENT.	SAMPLE DATE	MINE	SAMPLE LOCATION	CBDC ID. SAMPLE TYPE	RUN NO.	CAL'D C.A.I.	CAL'D C.H.I.	OPERATOR COMMENTS \ DESCRIPTION
16	9	16-Dec-88	PRINCE	3 DECLINE	MUDSTONE	1	0.4	7	TO BE IDENTIFIED BY CBDC GEOLOGISTS
						2	0.7	6	(TESTED ON DEC. 19/88)
						3	0.5	6	
						4	0.1	6	
						5	0.5		
						AVG.	0.44	6	

CRITERIA FOR ABRASIVITY (CBCRL)

< 0.50	NOT ABRASIVE TO SLIGHTLY ABRASIVE
0.50 TO 0.99	SLIGHTLY ABRASIVE
1.00 TO 1.99	MODERATLY ABRASIVE
2.00 TO 3.99	VERY ABRASIVE
4.00 TO 5.99	EXTREMELY ABRASIVE
6.00 TO 7.00	QUARTZITIC

CRITERIA FOR HARDNESS (CBCRL)

TEST CURVE READING	TEST LOAD Kg	CORR. FACTOR	REPORTED C.H.I.
15	7	/ 3	5
15	20	X 1	15
15	40	X 2	30

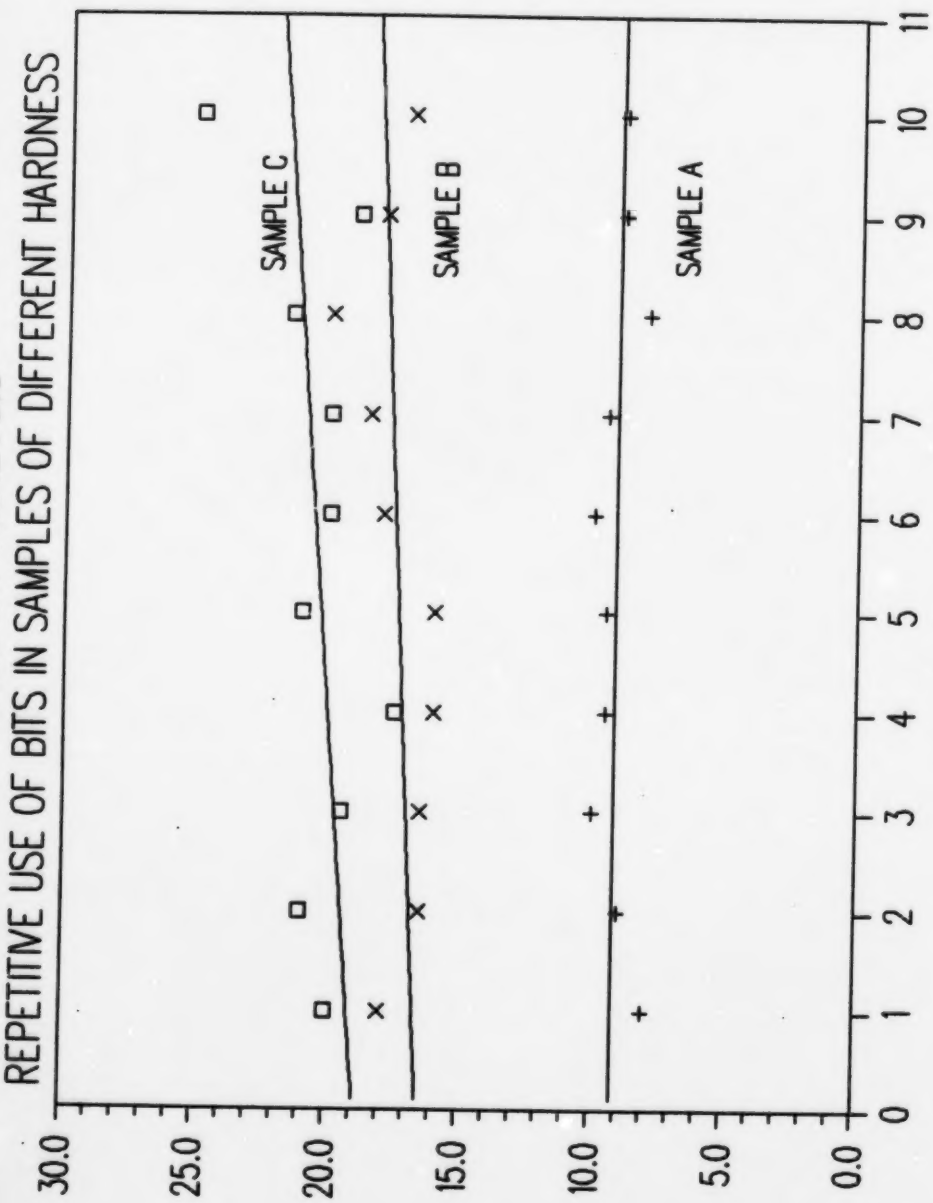


Figure 4 - Comparison of drill bit wear on samples with different degrees of hardness

be an indication of bit wear or inhomogeneity of the sample. The general trend shows that the bit performance is lessened with multiple tests. The effect is more pronounced with harder samples. It is possible that a hardness bit could be used more than once on softer samples, but more data is needed to confirm this hypothesis.

Table 4 shows the results of the hardness testing completed on nine samples taken from development faces at Prince Mine. These results may be used when considering the types of picks to use on roadheaders.

CONCLUSION

Preliminary testing of sandstone, siltstone and mudstone samples from Lingan Mine core samples reveals mean CERCHAR hardness indices of 21, 20 and 15 respectively. However, the test methodology has only just been established and it is now essential to develop a comprehensive data base, using samples representative of all the rock types encountered in the Sydney Coalfield, N.S.

Bit performance decreases when multiple testing of the same sample is undertaken using the same stylus. However, the effect is most pronounced with harder rocks and it is therefore tentatively suggested that for softer rock types, the stylus could be used up to three times before resharpening becomes necessary.

REFERENCES

1. Howarth, D.F. "Review of rock drillability and borability assessment methods"; Trans. Inst. Min. Metall., Section A, Vol. 95, pp. A191-A202; October 1986.
2. Aston, T.R.C. "Proposed CBCRL/CBDC research program to investigate rock cuttability and machine performance in the Sydney Coalfield, N.S."; Division Report CRL 87-56(INT); CANMET, Energy, Mines and Resources Canada.

3. Musial, M.L., Corbett, G.R. and Aston, T.R.C. "A CERCHAR hardness test program methodology developed for the Sydney Coalfield, N.S."; CANMET Division Report CRL 88-74(TR); CANMET, Energy, Mines and Resources Canada; November 1988.

4. Corbett, G.R. and Aston, T.R.C. "A CERCHAR abrasivity test program methodology developed for the Sydney Coalfield, N.S."; CANMET Division Report CRL 88-70(TR); October 1988.

5. Musial, M.L., Corbett, G.R. and Aston, T.R.C. "Preliminary CERCHAR abrasivity data, Sydney Coalfield, N.S."; CANMET Division Report CRL 89-2(TR); January 1989.

6. "CERCHAR hardness and abrasivity operations manuals"; Laboratoires du CERCHAR, Centre d'Etudes et Recherches des Charbonnages de France.

APPENDIX A

Description of core samples*

Sandstone, Hole L-1, Box 2, 24.41' to 27.00'

Light to medium grey; fine grained; contains 30% laminated siltstone; entire unit is highly laminated; abundant carbonaceous material; gradational contact; competent (test sample footage - 25.33' to 26.08')

Siltstone, Hole L-1, Box 1, 0.00' to 24.41'

Medium grey; fine to medium grained; numerous fossiliferous pods; laminated wispy sandy sections; cross bedded in some places; micaceous; carbonaceous partings; gradational contact; competent (test sample footage - 10.92' to 11.67')

Mudstone, Hole L-1, Box 3, 44.00' to 49.24'

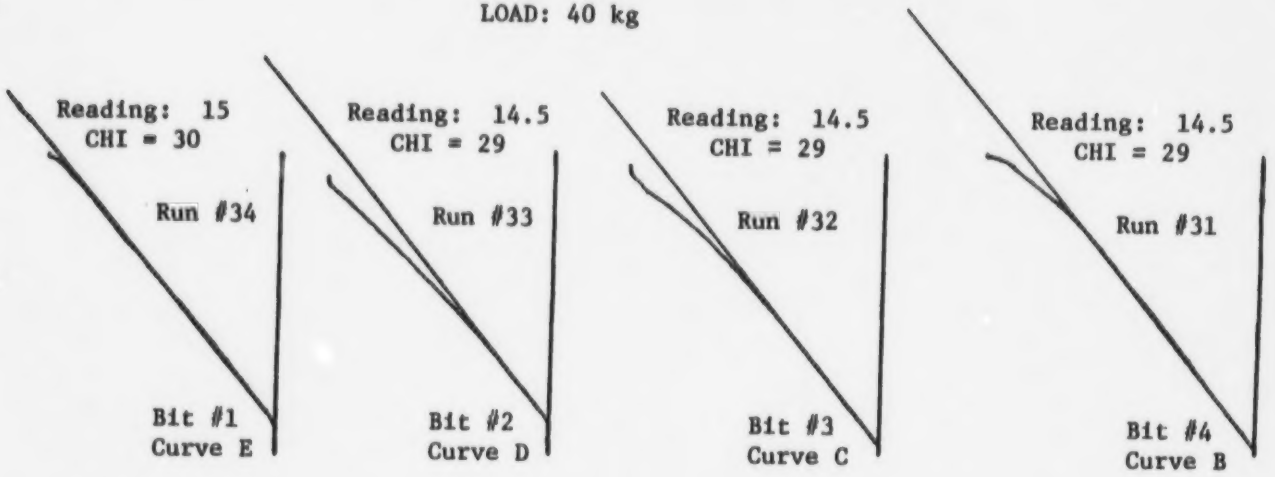
Medium to dark grey; very fine grained; fossiliferous; slightly banded; erosive contact (test sample footage - 44.58' to 45.25')

*Sample description supplied by geologists, Mine Engineering Department, Cape Breton Development Corporation.

APPENDIX B

SANDSTONE:

SEPT. 7/88
LOAD: 40 kg



Examples Only

APPENDIX C

HARDNESS TESTING PROCEDURE

The procedure supplied by CERCHAR contains various inaccuracies and ambiguities which necessitated revision by CBCRL staff. The updated procedure is as follows:

1) Ensure the 3-position switch is set at the zero (0) position before applying the main power supply. Set the spindle in place and lock. Raise the drill housing (i.e. the bit chuck) by means of the drill housing control wheel and lock into place.
2) Set test specimen in the vice of the hardness apparatus and grip securely. (Ideally, the rock sample must be sufficiently large for multiple testing). It is not necessary that the surface to be drilled is flat.
3) Insert a <u>used</u> bit into the chuck and tighten with the supplied allen key. Mount a ball pen in the pen holder and keep suspended above the drum roll. Place a recorder chart on the drum roll and fasten.
4) Unlock the spindle by means of the 3-arm handle. Set the pen on the chart recorder. Use the 3-arm hand wheel to actuate the spindle to obtain an origin line on the chart paper.
5) Relock the spindle and unlock the drill housing.
6) Turning the drill housing control wheel bring the locked spindle head close to the sample surface. When the bit comes into contact with the rock, the spindle will automatically unlock.
7) Turn on the compressed air to its maximum and ensure that it is properly directed at the site of the drill hole so that it forcefully clears away the rock dust immediately.
8) Grip the 3-arm handle with the right hand and set the 3-position switch on position one (1) with the left hand. Gently lower the spinning bit into the rock. The bit now penetrates the rock. When the bottom of the hole is perfectly circular (generally obtained at a very shallow depth), set the 3-position switch back to zero. Turn off compressed air. Relock the spindle by means of the 3-arm handle.
9) Unlock the drill housing and raise the bit by means of the drill housing control wheel. Relock the drill housing and remove the bit from the chuck.
10) Insert a new <u>unused</u> bit into the chuck.

11) Bring bit gently into contact with rock at the site of the starter hole as before - steps 5 and 6.
12) Ensure that the ball pen is positioned exactly at the origin. If the pen is not ideally set, maneuver the pen by turning the drill housing control wheel. Position the pen as desired, hold this position with the left hand and lock the drill housing in place with the right hand.
13) Turn on compressed air to its maximum. Ensure the penetration depth is set to 1.0 cm (see scale on the front of the apparatus).
14) Turn the 3-position switch on to the "rotation and recording" position (position 2). The bit automatically penetrates the rock and the depth of penetration is then recorded as a function of time.
15) Terminate drilling by turning the 3-position switch to zero. Turn off air. Raise pen from chart paper.
16) Raise the bit relock spindle by means of 3-arm handle. Unlock the drill housing and raise bit higher by means of the drill housing control wheel. Relock drill housing.
17) Leave used bit in to start drill hole for the next test. Raise ball pen and forward recording drum (set switch to position 2) to re-position chart paper for next curve. Chart paper may be used for several curves. Mark each card with an identification number and each curve with identification letter during testing.

<u>POINTS TO REMEMBER</u>:

1) Spindle set pins must be periodically checked to ensure they are properly tightened.
2) Drum roll's and drill head's revolution per minute should be periodically checked to ensure they remain constant. At present, the rpm of the drum roll is 0.50 revolution per minute, while the drill head is 120 revolutions per minute.